Investigation of the Dynamic Strength of Teeth with Prefabricated Casted Posts and Cores

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Summary

Partial or complete deficiency of the clinical crown of non-vital teeth leads to a certain degree of deficiency of the dental arch, and to a certain extent disturbed functioning of the masticatory system. In such cases it is necessary to construct posts and cores to strengthen the tooth abutment as the base for crowns and bridges.

The aim of the investigation was to compare the resistance of non-vital teeth, fitted with cast metal and prefabricated posts and cores, to dynamic loading in a high frequency pulsator, with special attention to different widths of root canal preparation.

The results of the fractographic analysis show that the greatest resistance to dynamic loading was found in teeth with narrow prefabricated posts and cores, which endured loading of 1000N for an average 7,497,318 cycles, without the occurrence of fracture. Widening of the root canal in the case of preparation of the intraradicular part of the tooth for posts and cores, of more than 3.5 mm, significantly reduced its retention and increased the possibility of root fracture. All fractures occurred in the tooth root, while the posts and cores retained intact.

Key words: *posts and cores, dynamic loading, fracture.*

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Introduction and aim of the investigation

The success of endodontic therapy involves the problem of reconstruction of damaged crowns of non-vital teeth. As such teeth are brittle and liable to fracture, particularly their functional crowns and even the roots, treatment of non-vital teeth from the biomechanical aspect is specific. Consequently, crown-root stabilisation is the fundamental biomechanical factor determining the success of treatment (1).

Technological advances have provided numerous techniques and materials for reconstruction of lost hard dental tissues, which for easy reference are classified as individual (cast), prefabricated (manufactured) and combined forms of posts and cores (2).

There is no agreement in the literature on which type is best. Authors recommend certain techniques based on their own research, experience and inclination. Each of the available methods has certain advantages and the success of therapy depends less on the technique chosen and more on its correct application and indication in a specific clinical case.

According to Reeh et al (3), loss of hard dental tissue during endodontic treatment of the canal does not essentially damage the tooth structure and leads to reduced hardness of approximately 5%. According to other authors (4-7) extensive loss of pericanal dentin during root canal cleaning and preparation necessarily weakens the tooth root.

Martinez et al. (8) compared the loading resistance of non-vital teeth with cast posts and cores and carbon fibre posts with composite reconstruction. The results of the investigation showed that the level of the loading fracture was significantly higher in the group with cast posts and cores, and breakage occurred within the root. The authors suggest that the material of the posts and cores must fracture before the effect of mechanical stress on the remaining dental structure.

Sidoli et al. (9) obtained similar results by testing Composipost system (RTD, Meylan, France) which showed poorer biomechanical characteristics compared to metal posts.

The aim of this investigation was to compare the resistance of non-vital teeth, fitted with cast metal and prefabricated posts and cores, to dynamic pulsatory loading in the compressive-tensile region of 800N-1000N, with special reference to different widths of root canal preparation.

Material and methods

The investigation included 48 human lower second premolars, of similar dimensions, extracted for orthodontic, periodontal or endodontic reasons. The tooth crowns were removed up to the cemento-enamel junction and roots endodontically treated up to size 40 and filled to the apex with Diamet (ESPE, Germany) and gutta-percha (Diadent, Korea) by lateral condensation technique. The prepared roots were divided into four groups of 12 samples, and each fitted with a post and core: 1. Prefabricated thread post and core with narrow intracanal post (post diameter 1.15 mm, diameter 1.45 mm; Maillefer, Switzerland, size 1), 2. Prefabricated thread post and core with wide intracanal post (post diameter 1.6 mm, diameter 1.95 mm; Maillefer, Switzerland, size 3B), 3. Individually cast post and core with narrow intracanal post (ellipsoid, diameter 1x2 mm), and 4. Individually cast post and core with wide intracanal post (ellipsoid, diameter 2x4 mm). All posts were 6 mm in length, which was also the depth of the insertion. The posts and cores were cemented with glass-ionomer cement (Fuji Plus GC Corporation, Tokyo, Japan). The supracoronary part of the prefabricated posts and cores was made of Filtek™ (P60 (3M, USA) composite material.

The samples were tested by dynamic pulsation loading in an Amsler high frequency pulsator. Compressive-tensile loading of 800N ± 15% up to 1000N ± 15%. The sample was secured to the floor of the pulsator by a specially constructed device. Dynamic loading values were determined in accordance with the number of cycles needed up to the occurrence of fracture, which determined the end of the test (Figure 1).

Results

The results of the investigation confirmed that the magnitude of the dynamic loading was inversely proportionate with the number of cycles up to the occurrence of cracks or fractures. Examination of the dynamic durability of the prefabricated and cast posts and cores showed that the prefabricated posts and cores were more resistant in all segments of the investigation. By comparing the sub-groups with narrow posts it was found that the cast posts and cores endured 2.928.963 (32.3%) less cycles during dynamic loading of 800N, and 2.626.089 (35%) less cycles during loading of 1000 N, than the prefabricated posts and cores. Difference was also recorded between the subgroups of posts and cores with wide posts, again in favour of the prefabricated posts and cores. During the effect of the same forces, amounting to 800N, the cast posts and cores endured 791.187 (12.5%) less cycles, and during the effect of force of 1000N 1.560.033 (30.6%) fewer cycles than the prefabricated posts and cores (Table 1). This difference can be explained by the loss of the basic advantage of cast posts and cores over prefabricated posts and cores, i.e. its tight adherence to the pericanal dentin walls, which is not revealed during of the preparation for prefabricated post with calibrated burs. In addition, the thread of the intracanal post, used in the investigation, contributes to its stability and retention within the root canal. The cast posts and cores are of conical shape, and during loading act like a wedge, causing a fissure in the tooth. This negative factor is neutralised by the construction of a cylindrical prefabricated post, with which the loading is more symmetrically distributed within the root, and the force is carried in an apical direction. During the cementation of cast posts great hydrostatic pressure occurs which causes surplus cementing material to effect the lateral root walls, which is avoided with the prefabricated post by the construction of proximal grooves.

During all the loading tests the groups of prefabricated posts and cores endured a greater number of cycles than the groups of cast posts and cores. Subgroups of posts and cores with narrow posts showed better properties compared to the subgroups with wide intracanal posts (Table 2). Analysis of variance with two varying factors (type of post, level of loading) for the prefabricated posts and cores showed significant difference in dynamic endurance ($p<0.01$) between the width of the post and core and the level of loading for both types of posts and cores (Table 3) in which the width of the post accounted for approximately 76% of the variability of results. Analysis of variance for the cast posts and cores also showed significantly different influence of the width of the post and core and loading, in which changed loading accounted for approximately 50% of the variability of the result, and statistically significant interaction was determined ($\alpha = 0.0239$;2.39%) (Table 4).

Discussion

In the literature few investigations can be found on dynamic strength of materials, mainly because of the long duration and high cost. Furthermore, it is difficult in vitro to adapt to conditions which exist in vivo, particularly because of the various mechanical and physical properties of the materials incorporated in the examined samples. However, such investigations have great value because they imitate natural loading relationships in the mouth, although the neurophysiological reaction of the muscles regulating mastication forces is difficult to imitate.

Ćatović (10, 11) investigated the dynamic strength of the human premolars with regard to the type of preparation for veneer crown, and observed that prepared teeth are more susceptible to crown fracture than intact teeth. Poljak-Guberina et al (12) determined inversely proportionate correlation of the magnitude of the dynamic loading and dynamic durability during an investigation of the dynamic durability of the compound Duceragold ceramic and Ag-Pd alloy, with and without prior thermocycling. Ćatić (13) also registered inversely proportionate correlation of the magnitude of dynamic loading and dynamic durability by investigating the effect of different types of preparations of the frontal teeth on the dynamic durability of provisional crowns, with and without prior thermocycling. Compared with our investigation results it is evident that during identical forces prefabricated and cast posts and cores endure significantly more cycles than acrylic and ceramic crowns, which confirms the durability of these posts and cores.

Investigations of prefabricated posts and cores of other authors show nonconformity of results, which is a consequence of the large number of different prefabricated post and core systems. Cohen et al. (14) investigated the resistance to cyclic loading of five systems of prefabricated posts and cores (Access Post, Flexi Flange, Flexi Post and Vlock) with four core materials (Tytin silver amalgam, Ti-Core, Ketac Silver and GC miracle Mix). The samples were loaded with 22.2N during 4 million cycles or up to fracture of the sample. All samples with Ti-Core composite or Tytin silver amalgam cores endured the planned maximum number of cycles without fracture. Samples with Ketac Silver and Miracle Mix cores fractured and failed to endure 4 million cycles. All fractures occurred within the core. The authors considered that a test of 4 million cycles corresponds to 10-year clinical use, referring to the claim by Huysmans and Van der Varst (15) who determined that a model with 5 million loading cycles corresponds to clinical use of 5 to 15 years. In our investigation the prefabricated posts and cores endured more cycles during greater dynamic loading. In addition, all fractures during our investigation occurred in the root, which confirms the resistance of all parts of the prefabricated posts and cores, while in the investigation by Cohen et al. (14) the fractures occurred within the core.

Although study of the dynamic durability of composite materials and glass ionomer cements was not the object of our investigation, the structure of the composite material proved to be more resistant to fracture than glass ionomer. Thus, this factor gains importance when such materials are a part of a system for reconstruction of non-vital teeth, as they can have an effect on the durability of posts and cores. In a comparative study of the strength of cast gold and composite pin retained posts and cores, Peres, Howe and Svare (16) concluded that the composite posts and cores were at least four times more durable than the cast gold posts and cores.

The effect of cyclic loading on retention of posts and cores was investigated by Stegariou et al. (17). Their results indicated that dynamic loading had a greater effect on prefabricated posts and cores, in which retention was significantly reduced after loading, which they explained by the loading effect on the cement used to cement the posts and cores into the root. In conclusion the authors emphasised that when wide preparation of the root canal is necessary posts which tightly adhere to the root canal walls can be more retentive.

The results of our investigation agree with those of Sorensen and Engelman (18), who examined the effect of post adaptation in the root canal to the fracture resistance of non-vital teeth. They concluded that posts with parallel sides fracture less frequently, and that during fracture less tooth structure is involved. Maximal adaptation of the post in the root canal significantly increases the fracture threshold. Conical posts result in extensive fractures, involving more tooth structure, in an apical direction. The authors conclude that conical posts should be used with extreme caution. Their conclusions contradict the claims of Berman et al. (19) who recommend conventional individual cast posts and cores.

Conclusions

1. From the results of the fractographic analysis it can be concluded that greatest resistance to dynamic loading was determined in teeth with narrow prefabricated posts and cores, which endured loading of 800N for 9,050,622 cycles without fracture.
2. Teeth with wide cast posts and cores were least resistant to fracture, and only endured loading of 800N for 3,522,611 cycles.
3. Widening of the root canal during intraradicular preparation by more than 3.5 mm significantly reduced retention of cast posts and cores and increased the possibility of root fracture.
4. In all groups of samples inversely proportionate relationship was determined between the magnitude of the dynamic loading and the number of cycles.
5. All fractures of the examined posts and cores were located within the root, while the posts and cores remained intact.
6. Presentation of the results of dynamic endurance by "box-wisker technique" on logarithmically converted data shows uniform distribution of the results of dynamic resistance for prefabricated posts and cores in contrast to the non-uniform distribution for cast posts and cores, demonstrating greater resistance to dynamic loading and better intraradicular retention of the prefabricated posts and cores.